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(54) **Methods of brazing adjoining surfaces of elements, brazing alloys, and structures comprising brazed joints.**

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PATENTS ABSTRACTS OF JAPAN, vol. 4, no. 45(M-6)(527), 1980, page 121M6

IBM TECHNICAL DISCLOSURE BULLETIN, vol. 21, no. 8, January 1979, page 3118, New York, USA; N. AINSLIE et al.: "Au/Sn/Ag braze alloy"

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Description

This invention relates to methods of brazing adjoining surfaces of elements, and structures comprising brazed joints. More particularly, the invention is concerned with providing bonding alloys useful in electronic circuit interconnections of a chip carrying substrate and its flange in a manner compatible with the subsequent reheating of the chips to melt their solder connections to the substrate without weakening the bond between the pins or flange and the substrate.

Brazing of elements to electronic chip carrying substrates such as multilayered ceramic substrates requires a brazing or soldering material which remains strong at high temperatures used for rework, i.e., removal and replacement of chips on the substrate, with the heat being required for heating the lead-tin solder balls supporting the chips. A standard solution to this problem is to use gold-tin solder whose melting point subsequent to brazing is higher than the initial 280°C melting point.

Because circuit connection pins have tended to tilt out of alignment during rework heating, and because problems have arisen in flange sealing with numerous cycles of rework, in accordance with this invention the braze alloy is modified during brazing by adding copper to the brazing material (which raises the melting temperature subsequent to bonding by increasing the amount of the higher melting point b phase of the alloy in the braze material) and a metal such as nickel, palladium or another Group VIII metal (which will tend to draw tin out of the melt or to getter the tin thereby promoting the apparent ratio of gold and copper to tin and the formation of the b phase of the Au-Sn alloy thereby tending to raise the melting temperature of the brazed joint subsequent to cooling, even further as well as thickening the braze material).

United States Patent No. 3,648,357 of Green, "Method for Sealing Microelectronic Device Packages" is concerned with hermetically sealing of a Kovar and glass housing and a Kovar alloy (Ni, Fe, Co) cover together with an eutectic gold-tin solder. In the past, Green stated that (Col. 1, line 12 et seq.) such packages had been sealed by placing "... a solder preform between the periphery of the edges of the housing and the cover to be sealed together". Then the parts to be soldered together were "placed in a sealing machine and ... heated to a sufficient temperature to cause the solder to fuse onto the cover and housing. Unfortunately, imperfect hermetic seals result in a substantial portion of the packages so sealed. Not only may leaks in the seal result due to voids therein, but the temperatures necessary to melt the solder and form the seal may be sufficient to damage the microelectronic device contained in the package. ..." In Green, the approach was to coat an 80:20 Au:Sn preform upon both the housing flange and upon the mating surface of the cover which fits upon the housing. In that way, the preform solder halves can be joined together at a low temperature at which the solder melts requiring little heat so as to reduce damage to the microelectronic device. However, since the Kovar alloy reacts badly with Au:Sn solder, the surfaces of Kovar alloy are first coated with gold by plating. Then the preforms are soldered to the plated housing and cover. The pretinning had the disadvantage that it raised the temperature of melting of the solder to the degree that the gold is melted from the Kovar plated surfaces. The purpose of the Green patent was to keep the melting point down to about 330°C rather than the 400°C temperature which would result with melting of the gold into the solder under equilibrium conditions. Use of the lower temperature assures that at equilibrium only a portion of the plated gold "will be dissolved into the solder". We have discovered that substitution of copper for gold in a bonding alloy has similar advantages with considerable cost advantages because of the lower cost of copper as a material.

A current practice in the industry is to join pins composed of Kovar alloy with a thin film of palladium with nickel pads deposited upon a thin film of molybdenum. The solder used is an Au:Sn brazing alloy. The Pd layer melts away after about four of the ten solder reflows one would expect under current practices in microelectronic circuit manufacture. A problem of leaching of Ni from the Kovar alloy pins and the pad below into the braze results. The leaching results in poor adhesion, causing rejection of the entire device. Accordingly, it is the desideratum to be able to reheat the braze repeatedly during such reflows with freedom from the remelting of the braze and consequent introduction of impurities into the braze which would ruin the product because of such weakening of the interface with the Kovar alloy.

Ainslie et al., "Au/Sn/Ag Braze Alloy", IBM Technical Disclosure Bulletin, Vol. *21, No. 8*, p. 3118 (Jan. 1979), describes a braze alloy (67 Au/15 Sn/18 Ag) for electronic packaging for Be-Cu contact pins or Kovar (Ni, Co, Fe) pins. In either case, there is either a member of the Group IB of the Periodic Table of the Elements (Cu) or a Group VIII metal (Ni, Fe, Co) in the Be-Cu or Kovar pins which fails to have the effect provided in accordance with the present invention. In addition, the alloy of the ratio of 67 Au to 15 Sn is not the low melting 80/20 eutectic ratio which permits low temperature brazing of the alloy, followed by formation of a higher melting temperature braze joint. Thus, the temperature effect is the opposite of what is desired here. The 18% of Ag in the alloy, however, acts as a substitute for gold since it is a Group IB metal which raises the melting point of the resulting alloy. Further, Ag as an alloying constituent, is expensive relative to Cu.

Accordingly the present invention provides a substrate including a pad composed of a thin film of nickel coated with a thin film of a metal selected from the group including copper, gold and palladium, the pad being juxtaposed with a preform consisting of three layers with the upper and lower layers being thicker and composed of Au : Sn and the middle layer comprising a thin film of a metal selected from the group consisting of copper, gold, silver and palladium, and a mounting flange juxtaposed with the preform and having an upper surface coated with a layer of a composition selected from the group consisting of Group IB metals and combinations of Group VIII metals, with copper included in the metal of at least one of the pad coating thin film, the middle layer of the preform and the coating layer of the flange.

Suitably the substrate includes a pad in which the pad coating thin film is of copper.

In a preferred embodiment of the present invention the middle layer of the preform is a thin film of copper.

Suitably the coating layer of the flange is of copper, with a coating layer for the flange of copper and nickel being preferred.

The invention will now be further described with reference to the accompanying drawings, in which:—

FIG. 1 shows a perspective, partially sectional view of the upper surface of a substrate carrying a large number of semiconductor chips. The substrate is mounted upon a flange. On the lower surface of the substrate are the pins shown of the type disclosed in EP—A—0055378.

FIG. 2 is an enlarged, front elevational view of the section shown in FIG. 1. The braze joints of the flange and the pins to the substrate are shown.

FIG. 3 is a graph of pin pull strength as a function of the number of 350°C thermal cycles to which the band is heated subsequent to brazing.

The problems solved by this invention relate to the brazing of the substrate to a flange used to support the substrate carrying chips and to provide for clamping in a hermetically sealed chip packaging arrangement.

A braze in accordance with this invention is suitable for electronic packaging of components together such that the braze joints thus produced exhibit melting temperatures that are substantially higher than those of the original braze alloy used in the operation. This feature is especially important when the brazing operation produces a braze joint having a melting temperature that is normally lower than the temperature at which subsequent manufacturing operations must occur. An example is the brazing of nickel plated multilayered ceramic structures at 400°C using Au-20 wt. % Sn braze alloy (melting point 280°C *prior* to one or more 350°C chip joining operations). The problem is that the braze joint experiences partial melting at 350°C with its many attendant undesirable effects, included among which are:

1. Relative motion between the members that were joined.

2. Diffusion of Sn from the braze joint to the nickel plated surfaces to form Ni-Sn intermetallics, thus depleting the surfaces of unreacted nickel which is essential for good adhesion.

3. Collapse and distortion of the Au-Sn fillet due to out-diffusion of tin and due to run-out of the liquid phase of the braze fillet at 360°C, with its attendant loss of strength and side support in the case of I-O pins.

The present invention includes applying thick copper, or copper-rich layers (0.0001—0.002 inch thick) onto one or both of the surface to be brazed together by any appropriate means, say electroplating electroless plating, vacuum deposition or silk screening.

The basis of the invention can be understood in relation to the Au-Sn phase diagram, and in relation to copending European patent application No. 81109164.4 in which the surfaces being brazed together are plated with thick gold layers.

When Au-20 wt. % Sn braze alloy cools to room temperature it is comprised of two phases, the brittle Au-Sn compound and the ductile, gold-rich phase. The alloy has a melting point of 280°C. Increasing the gold content of the alloy decreases the amount of Au-Sn present at room temperature, and also increases the liquidus temperature. Thus upon reheating, say to 350°C, the alloy melts only partially. If enough gold is added to the basic alloy, say enough to bring it to the Au-10Sn composition, there will be no partial melting at all at 350°C, and there would be no brittle Au-Sn phase in the structure at room temperature. Therefore, by providing thick gold layers on one or both of the surfaces being brazed together, it is possible to accomplish these desirable results, and to reduce or eliminate the undesirable effects enumerated previously, by means of a solid-liquid reaction that occurs at the brazing temperature between the liquid braze alloy and the gold surfaces. A braze joint having a melting point much higher than the original braze alloy is the result.

In accordance with the present invention the thick gold layers are replaced by copper, copper-rich layers, or by solid copper or copper-rich parts. The copper partially substitutes for gold in the desirable phase discussed above, thus providing a cheap and relatively simple alternative in accomplishing the results cited above. In accordance with the invention, the process is as follows: 1) braze at the standard braze temperature (say 400°C) to form the joint and to establish the limits of the fillet, 2) hold at this temperature sufficiently long to allow some uptake of copper to occur with its concomitant partial solidification, 3) raise the temperature (say to 425°—475°C) to allow the copper uptake reaction to occur more completely without fear of flowout ("pin climb"), and 4) cool to room temperature.

FIG. 1 shows a square substrate 10 carrying 100 chips 30 with the substrate 10 brazed to a square mounting flange 32 with a lower flange surface 33 carrying the substrate by braze metal 31 on the periphery of the substrate 10. Beneath the substrate 10 are pins 19. Flange 32 includes an upper surface 34 extending about the top of flange 32. Surface 34 also forms the periphery of flange 32, whereas surface 33 forms the inner frame of flange 32.

FIG. 2 shows the substrate 110 carrying chips and having a pad 114 on the lower surface composed of a thin film of nickel coated with a thin film 113 of copper. A preform 120 consists of three layers with the thicker layers 121 and 123 on the top and bottom composed of near eutectic Au-Sn. In the center of the preform 120 is a thin film 122 of copper, which provides a source metal which will increase the melting point of the braze as above. The mounting flange 133 is composed of Kovar alloy coated with a layer 134 of copper or a combination of copper plus a Group VIII metal such as Ni as described above. Examples of layer 134 composition include Cu, CuNi, AuCuNi, etc.

The preform 120 is about 11—12 mils (.28—.30 mm) thick. The substrate is about 2.5 to 5 mm thick, and the flange 132 is about 0.6 mm thick. When the braze is heated, the result is very similar to the results achieved above in that the additional copper and Group VIII metals in the alloy increase the melting temperature above the 80/20 Au-Sn eutectic temperature.

In a modification of the Fig. 2 construction, the copper film 113 may be replaced by a gold or palladium film and the film 122 by Au-Cu, Au, Ag or Pd. The metal coating layer 134 can include a Group IB metal other than copper e.g. Au, Ag or Pd or a combination of a Group IB metal with a Group VIII metal such as Fe, Co, Ru, Rh, Pd, Os, Ir and Pt. The modified construction comprises a substrate including a pad composed of a thin film of nickel is coated with a thin film of a metal selected from the group including copper, gold and palladium, said pad being juxtaposed with a preform comprising three layers with the upper and thicker layers comprising Au:Sn and the middle layer comprising a thin film of a metal selected from the group consisting of copper, gold, silver and palladium, and a mounting flange juxtaposed with said preform having an upper surface composed of a composition selected from the group consisting of Cu, AuCu, CuNi, and AuCu, Ni with copper included in at least one of said pad, said preform and said flange.

FIG. 3 shows the results of pin pull strength testing as a function of the number of 350°C thermal cycles. The upper curve is for pins of about 0.94 mm diameter composed of BeCu and the lower curve is for pins of about 0.71 mm diameter of BeCu with a brazing material of Au-20 wt. % Sn.

Claims

1. A substrate including a pad (114) composed of a thin film of nickel coated with a thin film (113) of a metal selected from the group including copper, gold and palladium, the pad (114) being juxtaposed with a preform (120) consisting of three layers (121, 122, 123) with the upper and lower layers (121, 123) being thicker and composed of Au:Sn and the middle layer (122) comprising a thin film of a metal selected from the group consisting of copper, gold, silver and palladium, and a mounting flange (133) juxtaposed with the preform (120) and having an upper surface coated with a layer (134) of a composition selected from the group consisting of Group IB metals and combinations of Group IB and Group VIII metals, with copper included in the metal of at least one of the pad coating thin film (113), the middle layer (122) of the preform (120) and the coating layer (134) of the flange (133).

2. A substrate according to claim 1, in which the pad coating thin film (113) is of copper.

3. A substrate according to claim 1 or 2, in which the middle layer (122) of the preform (120) is a thin film of copper.

4. A substrate according to claim 1, 2 or 3, in which the coating layer (134) of the flange (133) is of copper.

5. A substrate according to claim 1, 2 or 3, in which the coating layer (134) of the flange is of copper and nickel.

Patentansprüche

1. Trägersubstrat mit einer Trägerschicht (114), bestehend aus einem dünnen Nickelfilm, der mit einem dünnen Film (113) aus einem Metall aus der Gruppe Kupfer, Gold und Palladium überzogen ist, wobei die Trägerschicht (114) an einem Vorformling (120) anliegt, der aus drei Lagen (121, 122, 123) besteht, von denen die obere und die untere Lage (121, 123) dicker und aus Au:Sn zusammengesetzt sind und die mittlere Schicht (122) aus einem dünnen Film aus Metall der Gruppe Kupfer, Gold, Silber und Palladium besteht, und mit einem Anbauflansch (133), der an dem Vorformling (120) anliegt, mit einem Oberflächenüberzug mit einer Schicht (134) aus einer Zusammensetzung von Metall der Gruppe IB und einer Kombination von Metallen der Gruppe IB und der Gruppe VIII, wobei dem Metall zumindest in einer Schicht von dem Überzugsfilm (113) der Trägerschicht, der mittleren Schicht (122) des Vorformlings (120) und der Überzugsschicht (134) des Flansches (133) Kupfer enthält.

2. Trägersubstrat nach Anspruch 1, bei welchem der Überzugsfilm (113) der Trägerschicht aus Kupfer besteht.

3. Trägersubstrat nach Anspruch 1 oder 2, bei welchem die mittlere Schicht (122) des Vorformlings (120) eine dünne Schicht aus Kupfer ist.

4. Trägersubstrat nach Anspruch 1, 2 oder 3, bei welchem die Überzugsschicht (134) des Halteflansches (133) aus Kupfer ist.

5. Trägersubstrat nach Anspruch 1, 2 oder 3, bei welchem die Überzugsschicht (134) des Flansches aus Kupfer und Nickel ist.

Revendications

1. Substrat comprenant un plot (114) constitué d'une couche mince de nickel revêtue d'une couche mince (113) d'un métal choisi dans le groupe comprenant le cuivre, l'or et le palladium, le plot (114) étant juxtaposé à une préforme (120) consistant en trois couches (121, 122, 123), les couches supérieure et inférieure (121, 123) étant plus épaisses et constituées de Au/Sn et la couche médiane (122) comprenant un film mince d'un

métal choisi dans le groupe comprenant le cuivre, l'or, l'argent et le palladium, et une bride de montage (133) juxtaposée à la préforme (120) et ayant une surface supérieure revêtue d'une couche (134) ayant une composition choisie dans le groupe comprenant des métaux du groupe IB et des combinaisons de métaux du groupe IB et du groupe VIII, du cuivre étant inclus dans le métal d'au moins l'une de la couche mince (113) revêtant le plot, de la couche médiane (122) de la préforme (120), et de la couche de revêtement (134) de la bride (133).

2. Substrat selon la revendication 1, dans lequel la couche mince revêtant le plot (113) est en cuivre.

3. Substrat selon l'une des revendications 1 ou 2, dans lequel la couche médiane (122) de la préforme (120) est une couche mince de cuivre.

4. Substrat selon l'une des revendications 1, 2 ou 3, dans lequel la couche de revêtement (134) de la bride (133) est en cuivre.

5. Substrat selon l'une des revendications 1, 2 ou 3, dans lequel la couche de revêtement (134) de la bride est constituée de cuivre et de nickel.

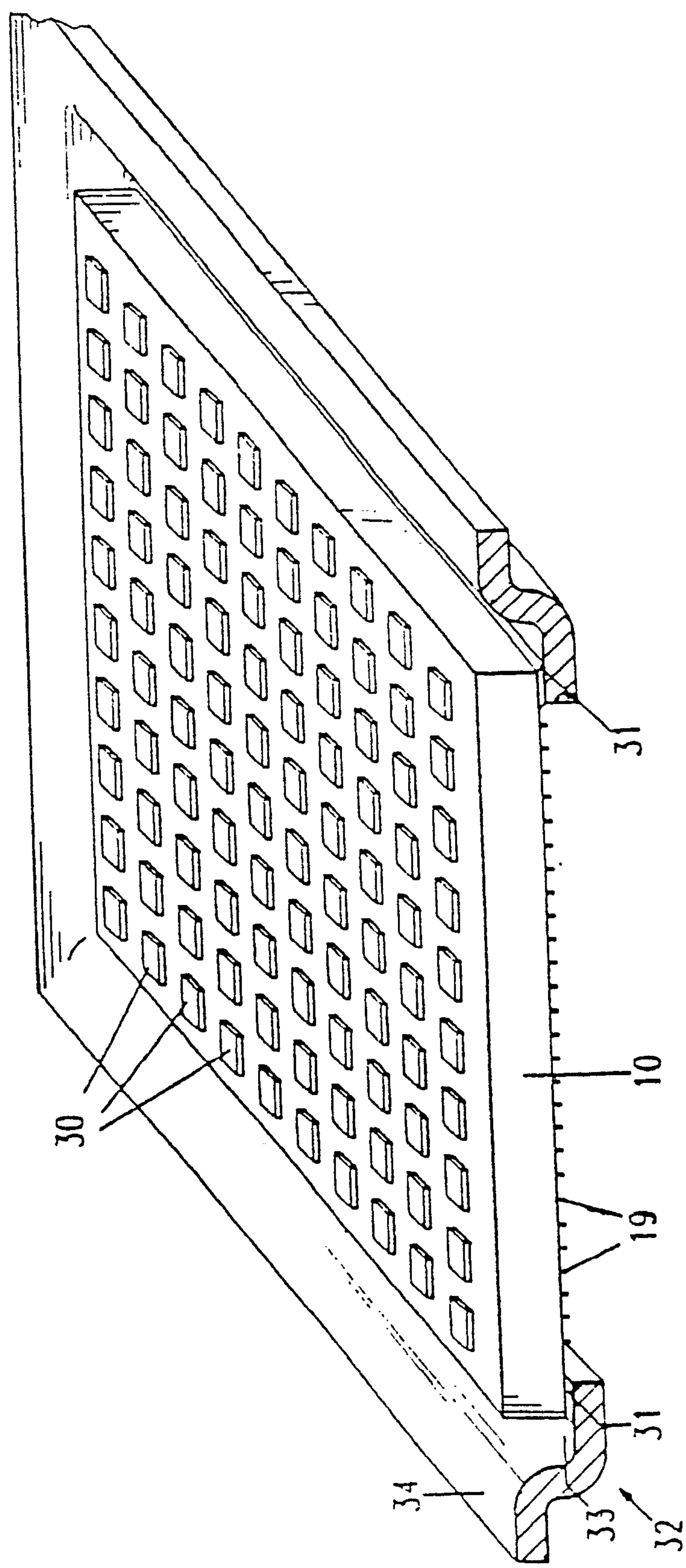


FIG. 1

FIG. 2

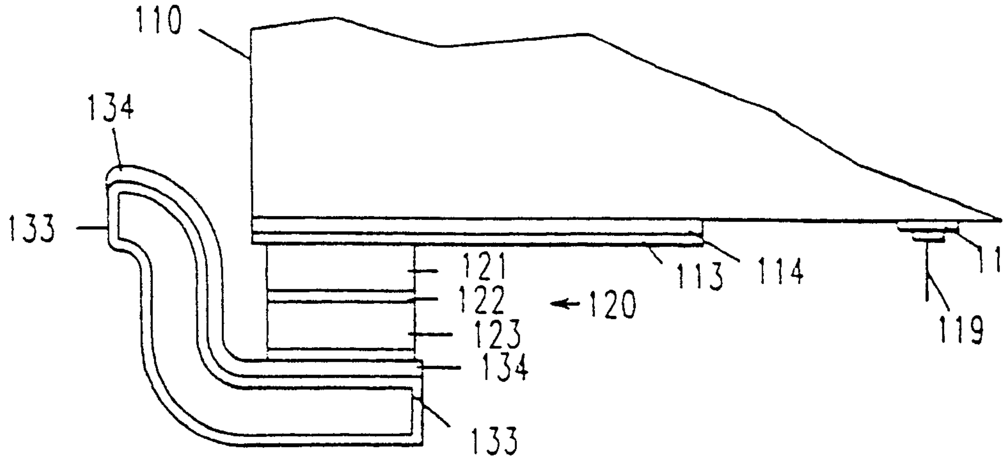
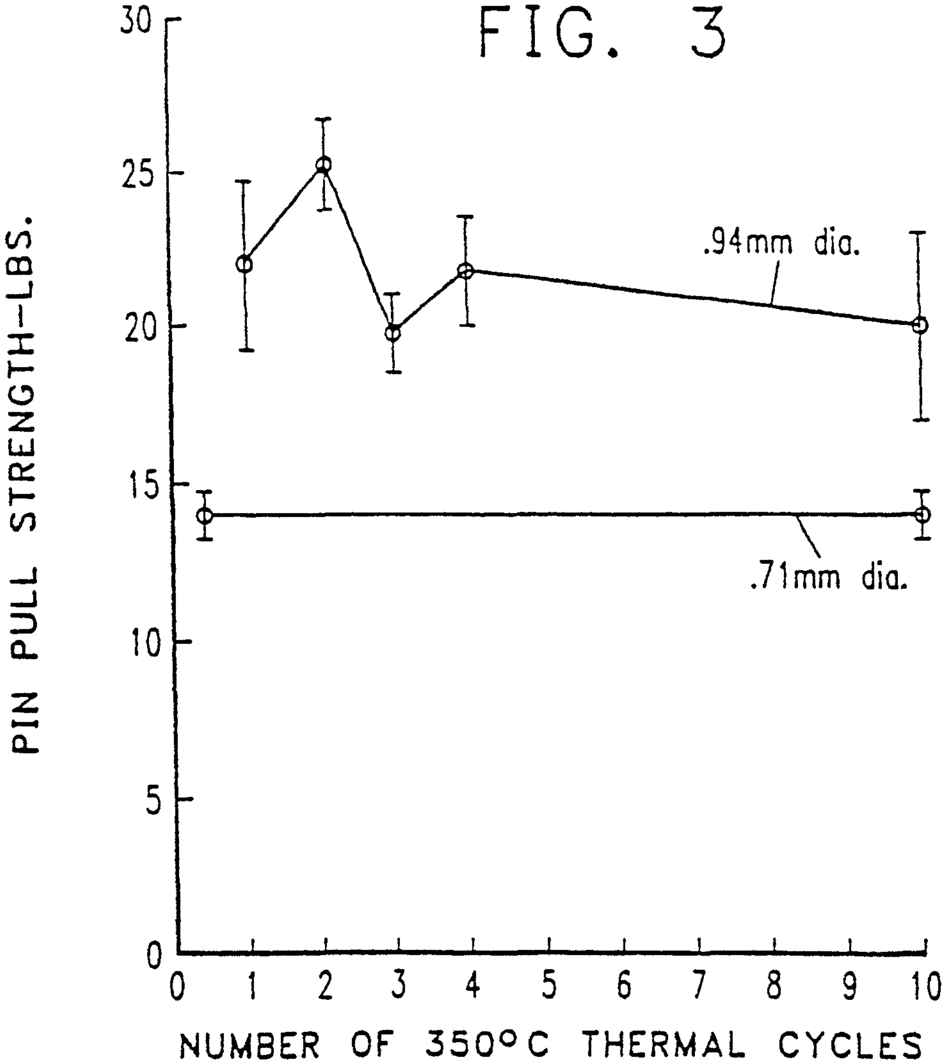


FIG. 3


30
25
20
15
10
5
0
PIN PULL STRENGTH–LBS.
.94mm dia.
.71mm dia.
0 1 2 3 4 5 6 7 8 9 10
NUMBER OF 350°C THERMAL CYCLES